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### (54) Surface mount antenna and communication apparatus including the same

(57) The invention provides a surface mount antenna (10), comprising: a substrate (2) made of at least one of a dielectric material and a magnetic material, said substrate (2) having a substantially rectangular prism shape and including a first major surface (2a) and a second major surface (2b); a ground electrode (3) disposed on said first major surface (2a) of said substrate (2); a radiation electrode (4) having a strip shape disposed at least on said second major surface (2b) of said substrate (2); a feeding electrode (5) disposed on at least one surface of said substrate (2); and said radiation electrode (4) including an open end portion (4a) and a plurality of grounded end portions (4b, 4c), said open end portion (4a) being arranged close to said feeding electrode (5) with a gap therebetween on said substrate (2), and said plurality of grounded end portions (4b, 4c) being connected to said ground electrode (3) on different portions of the substrate (2), respectively.

The above described antenna has an enhanced gain without changes in size.

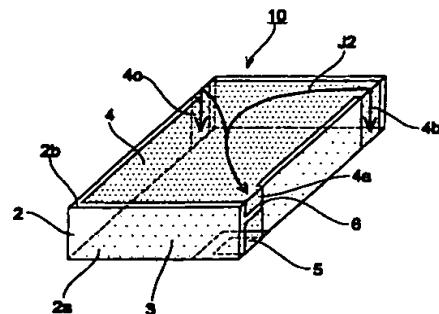


Fig. 1

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## Description

### BACKGROUND OF THE INVENTION

#### 1. Industrial Field of the Invention

**[0001]** The present invention relates to a surface mount antenna and a communication apparatus including the same.

#### 2. Description of the Related Art

**[0002]** Fig. 4 shows a conventional surface mount antenna. The basic configuration of the surface antenna is stated in Japanese Unexamined Patent Publication No. 9-098015. In the surface mount antenna 1 shown in FIG. 4, a ground electrode 3 is provided on a first major surface 2a of a substrate 2 made of a dielectric such as a ceramic, a resin, and the like, having a substantially rectangular prism shape. A strip radiation electrode 4 is provided on a second surface 2b. A feeding electrode 5 is provided on the first major surface 2a, turning to and elongating on one end surface of the substrate 2. The radiation electrode 4 is provided on substantially the entire surface of the second major surface 2b of the substrate 2, in a straight strip shape. In one end of the radiation electrode 4, an open end portion 4a is so provided as to extend and turn to the end surface in which the feeding electrode 5 is provided, till it is close to the feeding electrode 5 through a gap 6. In the other end of the radiation electrode 4, a grounded end portion 4b is so provided as to extend and turn to and on the end surface of the substrate 2 in which the feeding electrode 5 is provided, till it gets into contact with the ground electrode 3.

**[0003]** With the above configuration of the surface mount antenna 1, a high frequency signal, inputted into the feeding electrode 5, is transmitted to the radiation electrode 4 through a static capacitance produced in the gap 6 between the open end portion 4a of the radiation electrode 4 and the feeding electrode 5. The radiation electrode 4 of which one end is open and the other end is short-circuited, having a length of about  $\lambda/4$  becomes resonant as a microstrip line resonator. With the resonance, a part of an electric field energy generated between the radiation electrode 4 and the ground electrode 3 is radiated into space. Thus, the surface mount antenna 1 acts as an antenna. In FIG. 4, J1 designates an electric current flowing in the radiation electrode 4.

**[0004]** In a microstrip line resonator with a length of about  $\lambda/4$  such as the surface mount antenna 1, a current flowing there is maximum in the grounded end portion 4b. The grounded end portion 4b is so provided as to be narrow in width, as compared with the other part of the radiation electrode 4. Therefore, the current density in the grounded end portion 4b is higher than the other part of the radiation electrode 4. Accordingly, the conductor loss of the radiation electrode 4 is maximum

in the grounded end portion 4b.

**[0005]** FIG. 5 is a side view showing the end surface of the surface mount antenna 1 where the feeding electrode 5, the open end portion 4a of the radiation electrode 4, and the grounded end portion 4b are provided. As shown in FIG. 5, the current J1 flows in the grounded end portion 4b of the radiation electrode 4, concentratedly in the side of the grounded end portion 4b which is relatively near to the open end portion 4a, since the current J1 has a tendency to flow from the feeding electrode 5 to the ground electrode 3 a shortest distance, due to its electromagnetic characteristics.

**[0006]** As described above, the maximum current flowing in the radiation electrode 4 is concentrated in the side of the narrow grounded end portion 4b which is relatively near to the open end portion 4a. Therefore, the conductor loss in the above-mentioned side of the grounded end portion 4b is high, which causes the antenna gain to decrease.

**[0007]** It is thinkable that the width of the grounded end portion 4b is widened as measures for reducing the conductor loss. Even if the grounded end portion 4b is widened, a current flows concentratedly in the side of the grounded end portion 4b which is relatively close to the open end portion 4a. Accordingly, the antenna gain can not be improved. By widening the grounded end portion 4b of the radiation electrode 4, the distance between the grounded end portion 4b and the open end portion 4a becomes short. That is, the substantial length of the radiation electrode is shortened, causing the resonance frequency to increase. In order to restore the resonance frequency, it is necessary to lengthening the substrate 2 and the radiation electrode 4.

### SUMMARY OF THE INVENTION

**[0008]** Preferred embodiments of the present invention is provided to overcome the above described problems, and provide a surface mount antenna of which the antenna gain can be enhanced without changes in the size of the antenna, and a communication apparatus including the same.

**[0009]** The preferred embodiment of the present invention provides a surface mount antenna, comprising: a substrate made of at least one of a dielectric material and a magnetic material, said substrate having a substantially rectangular prism shape and including a first major surface and a second major surface; a ground electrode disposed on said first major surface of said substrate; a radiation electrode having a strip shape disposed at least on said second major surface of said substrate; a feeding electrode disposed on at least one surface of said substrate; and said radiation electrode including an open end portion and a plurality of grounded end portions, said open end portion being arranged close to said feeding electrode with a gap therebetween on said substrate, and said plurality of grounded end portions being connected to said ground

electrode on different portions of the substrate, respectively.

[0010] In the above described surface mount antenna, said plurality of grounded end portions may be connected to said ground electrode on different end surfaces of the substrate, respectively.

[0011] The preferred embodiment of the present invention provides a communication apparatus including the above described surface mount antenna.

[0012] According to the above described surface mount antenna, a plurality of branched grounded end portions are so provided in the other end of the radiation electrode as to elongate on the different end surfaces of the substrate to be connected to the ground electrode, respectively. Accordingly, a current flowing in the respective grounded end portions of the radiation electrode is reduced with the current density and the conductor loss. Thereby, the antenna gain of the surface mount antenna can be improved without changes in the size of the antenna.

[0013] And, according to the above described communication apparatus, the communication quality can be enhanced, and the expense of the communication apparatus excepting the antenna can be saved.

[0014] Other features and advantages of the present invention will become apparent from the following description of preferred embodiments of the invention which refers to the accompanying drawings, wherein like reference numerals indicate like elements to avoid duplicative description.

#### BRIEF DESCRIPTION OF DRAWINGS

##### [0015]

FIG. 1 is a perspective view of a surface mount antenna according to a preferred embodiment of the present invention.

FIG. 2 is a perspective view of a surface mount antenna according to another preferred embodiment of the present invention.

FIG. 3 is a perspective view of a communication apparatus according to a preferred embodiment of the present invention.

FIG. 4 is a perspective view of a conventional surface mount antenna.

FIG. 5 is a side view of a grounded end portion of the conventional surface mount antenna, in which a current distribution is illustrated.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] FIG. 1 shows a surface mount antenna according to a preferred embodiment of the present invention. In FIG. 1, two branched portions as grounded end portions 4b, 4c are so provided in the other end of the radiation electrode 4 of the surface mount antenna 10 as to

elongate on the opposite end surfaces of the substrate and be connected to the ground electrode 3, respectively. In FIG. 1, J2 designates an electric current flowing in the radiation electrode 4.

[0017] As described above, the branched grounded end portions 4b, 4c of the radiation electrode 4 are provided on the two opposite end surfaces of the substrate 2. A current, though it conventionally flows only through the grounded end portion 4b, is divided and flows through both of the grounded end portion 4b, 4c. The current density in the respective grounded end portions becomes about half as compared with the case of the current flowing through only one grounded end portion. Thus, the conductor loss in the respective grounded end portions 4b, 4c is reduced, and the antenna gain of the surface mount antenna 10 is improved. In addition, the grounded end portion 4b of the surface mount antenna 10 is in the same position as that of the surface mount antenna 1, and the grounded end portion 4c is provided in the opposite position to the grounded end portion 4b. Thus, the distances between the open end portion 4a and the grounded end portion 4b and between the open end portion 4a and the grounded end portion 4c are prevented from becoming short. Thus, even though the surface mount antenna 10 has the same size as the conventional surface mount antenna 1, the resonance frequency can be prevented from changing significantly.

[0018] FIG. 2 shows a surface mount antenna according to another preferred embodiment of the present invention. As shown in FIG. 2, three branched portions as grounded end portions 4b, 4c, and 4d are so provided in the other end of the radiation electrode 4 of the surface mount antenna 20 as to elongate on three different end surfaces of the substrate 2 to be connected to the ground electrode 3. In FIG. 2, J3 designates an electric current flowing through the radiation electrode 4.

[0019] In the surface mount antenna 20 as described above, by branching the grounded end of the radiation electrode 4 into three portions 4b, 4c, and 4d, currents flowing in the respective end portions 4b, 4c, and 4d can be more decreased as compared with the case of the surface mount antenna 10 as shown in FIG. 1, and thereby, the conductor loss can be further reduced. The antenna gain is enhanced.

[0020] As a result of the experiment, it was shown that in the case of the substrates having the same size, the surface mount antenna 10, 20 had antenna gains enhanced by 0.2 dB, 0.7 dB as compared with the surface mount antenna 1, respectively. Thus, the improvement of the antenna gain has been confirmed.

[0021] In the above-described respective embodiments, the radiation electrode is provided in a wide straight shape. However, the radiation electrode may have another shape such as a L-shaped, U-shaped, a meander shape, or the like. In the above-described embodiments, the substrate of the surface mount antenna is made of a dielectric. However, for the

substrate, magnetic material such as ferrite and the like may be used.

[0022] Fig. 3 shows a communication equipment including the surface mount antenna 10 of the present invention. As regards a communication apparatus 30 shown in FIG. 3, a mounting substrate 32 is provided in a case 31. On the mounting substrate 32, a ground electrode 33 and a feeding line 34 are provided. The surface mount antenna 10 is mounted in a corner of the mounting substrate 32. The feeding terminal (not shown) of the surface mount antenna 10 is connected to the feeding line 34 of the mounting substrate 32. The feeding line 34 is connected to a transmitting circuit 36 and a receiving circuit 37 provided on the mounting substrate 32, through a change-over circuit 35 provided on the mounting substrate 32.

[0023] As seen in the above description, the communication apparatus 30, using the surface mount antenna 10, has an improved antenna gain. Accordingly, the communication apparatus 30 has high anti-noise properties, and communication can be achieved on a low signal level. That is, the communication quality is enhanced. On the other hand, specifications of NF (noise factor) of a filter and a mixer, and the C/N ratio (noise ratio) of an oscillator in the communication apparatus may be slacked in consideration of the improved gain. Thus, the cost of components except the antenna can be lowered. Thus, the total expense of the communication apparatus 30 can be saved.

[0024] In the embodiment as shown in FIG. 3, the communication apparatus 30 is constructed by using the surface mount antenna 10 as shown in FIG. 1. The communication apparatus provided configured by using the surface mount antenna 20 as shown in FIG. 2 presents the same operation/working-effect as one containing the surface mount antenna 10.

[0025] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the forgoing and other changes in form and details may be made therein without departing from the spirit of the invention.

## Claims

1. A surface mount antenna (10, 20), comprising:

a substrate (2) made of at least one of a dielectric material and a magnetic material, said substrate having a substantially rectangular prism shape and including a first major surface (2a) and a second major surface (2b);  
 a ground electrode disposed on said first major surface (2a) of said substrate (2);  
 a radiation electrode (4) having a strip shape disposed at least on said second major surface (2b) of said substrate (2);  
 a feeding electrode (5) disposed on at least

one surface of said substrate (2); and  
 said radiation electrode (4) including an open end portion (4a) and a plurality of grounded end portions (4b, 4c), said open end portion (4a) being arranged close to said feeding electrode (5) with a gap therebetween on said substrate (2), and said plurality of grounded end portions (4b, 4c) being connected to said ground electrode (3) on different portions of the substrate (2), respectively.

2. The surface mount antenna (10, 20) according to Claim 1, wherein said plurality of grounded end portions (4b, 4c) are connected to said ground electrode (3) on different end surfaces of the substrate, respectively.
3. A communication apparatus (30) including the surface mount antenna of Claim 1.
4. A communication apparatus (30) including the surface mount antenna of Claim 2.

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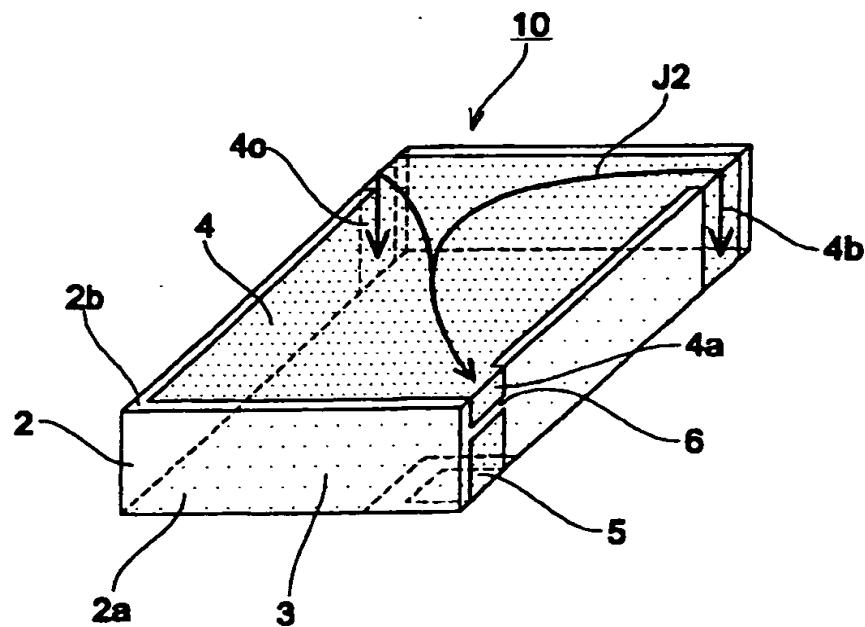


Fig. 1

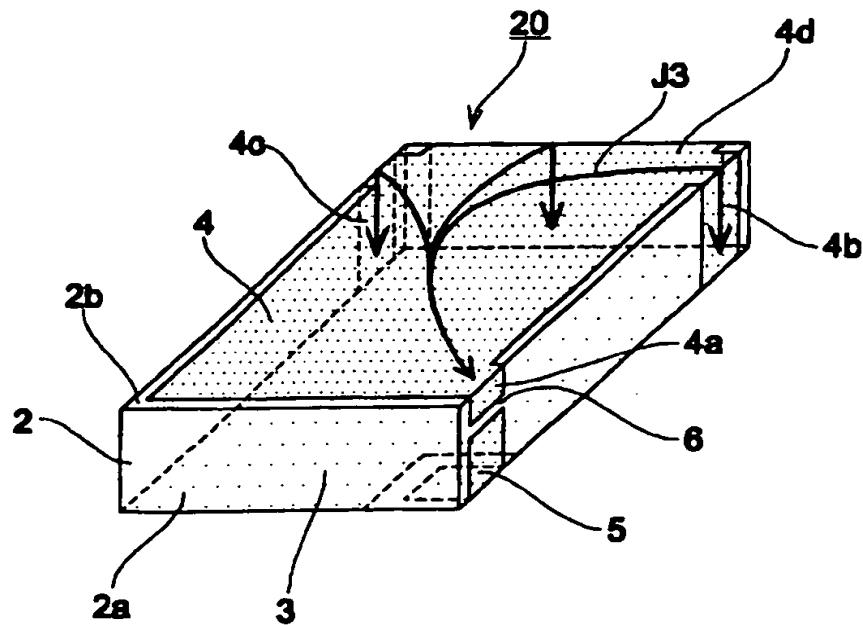
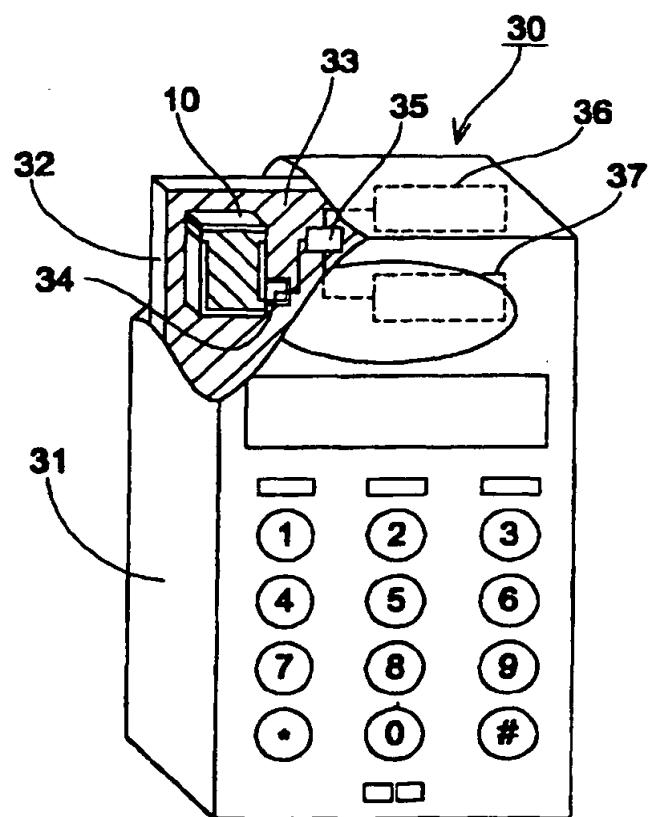
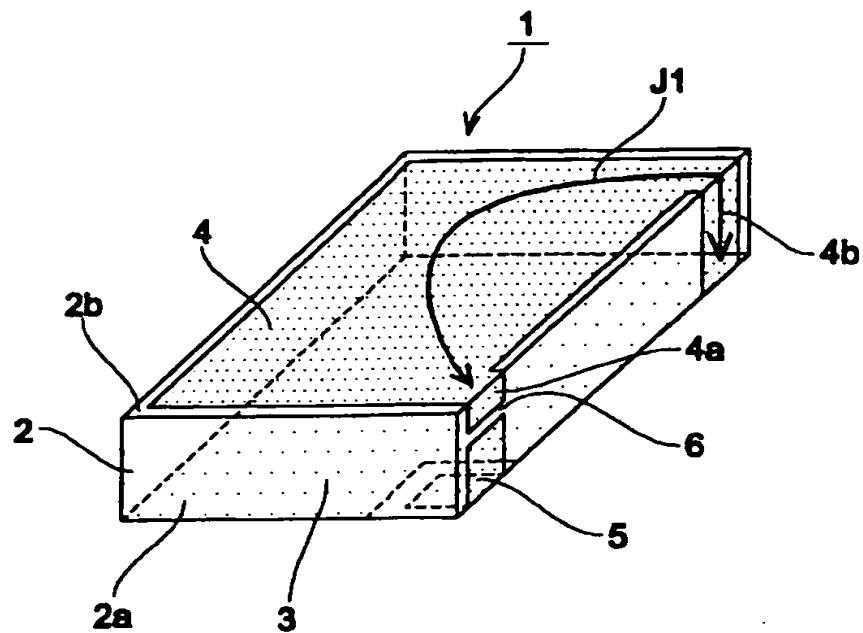


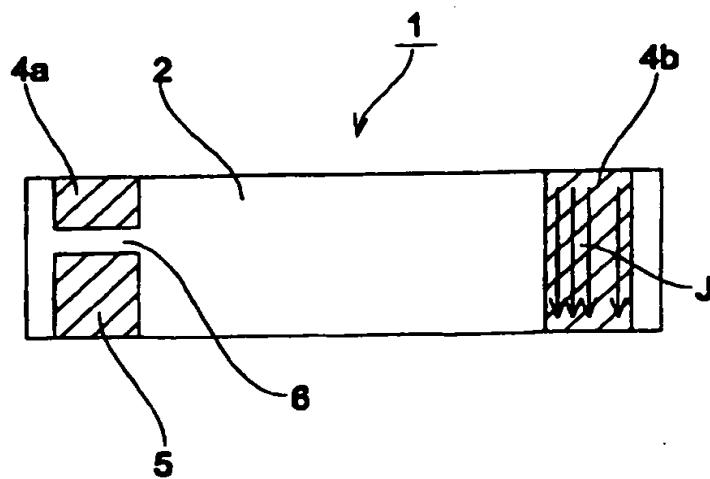
Fig. 2



**Fig. 3**



**Fig. 4    PRIOR ART**



**Fig. 5    PRIOR ART**



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## EUROPEAN SEARCH REPORT

Application Number  
EP 98 12 3649

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP 0 766 341 A (MURATA MANUFACTURING ) 2 April 1997 * column 4, line 9 - column 6, line 15; figures 1-6 *	1-4	H01Q1/38 H01Q9/04 H01Q1/24
D	& PATENT ABSTRACTS OF JAPAN vol. 097, no. 008, 29 August 1997 & JP 09 098015 A (MURATA MANUFACTURING), 8 April 1997 * abstract *		
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Y	US 4 367 474 A (SCHAUBERT ET AL.) 4 January 1983 * column 2, line 48 - column 3, line 5 * * column 4, line 11 - line 27 * * column 5, line 60 - column 6, line 6; figures 2A-6 *	1-4	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	GB 2 227 370 A (KOKUSAI ELECTRIC ET AL.) 25 July 1990 * abstract; figures 2A,B *	1-4	H01Q
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<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search		Examiner
THE HAGUE	30 March 1999		Angrabeit, F
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